CENTER FOR INSTITUTIONAL REFORM AND THE INFORMAL SECTOR

University of Maryland at College Park

Center Office: IRIS Center, 2105 Morrill Hall, College Park, MD 20742
Telephone (301) 405-3110 • Fax (301) 405-3020

**AN OPEN OR CLOSED TECHNOLOGY POLICY?
THE EFFECTS OF TECHNOLOGY LICENSES,
FOREIGN DIRECT INVESTMENT, AND
DOMESTIC AND INTERNATIONAL
SPILLOVERS ON R&D IN INDIAN FIRMS**

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Brian Fikkert
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Author: Brian Fikkert, Department of Economics, University of Maryland, College Park

An Ooen or Closed Technologv Policv?

The Effects of Technology Licenses, Foreign Direct Investment,

and Domestic and International Spillovers on R&D in Indian Firms

by

Brian Fikkert

IRIS summary

One of the chief objectives of the Indian government since independence has been to achieve technological self-reliance in the industrial sector, where "self-reliance" refers to the ability of Indian firms to invent and implement new technologies on their own without having to purchase such technologies from foreigners. To varying degrees over the past three decades, India has pursued this objective through the adoption of a "closed" technology policy designed to shield Indian firms from foreign influences in order to induce these firms to develop new technologies on their own. The three key features of this closed technology policy were: 1) the adoption of a relatively weak patent regime, 2) the limitation of foreign direct investment (FDI), and 3) the regulation of technology purchase (TP) licenses to varying degrees across different industries. These policies have been key points of contention between India and the United States.

As part of its current economic reform package, India has relaxed its restrictions on FDI and TP licenses, and stronger patent protection may be on the horizon following the Uruguay Round of the GATT negotiations. Of concern to many Indian policymakers is whether these regime changes will inhibit the development of an indigenous innovative capability, sacrificing

long-run self-reliance in exchange for what are perceived to be dubious short-run benefits.

Using panel data on 571 Indian firms from 1975/76-1978/79, a period in which all three features of India's closed technology policy were in place, the following paper estimates a model in which both R&D and TP are choice variables for which comer solutions, i.e. the choice of zero expenditures, are possible. Treating both R&D and TP as endogenous variables avoids the problems of simultaneity which have plagued previous studies and allows a proper examination of the effects of the technology licensing regulations on R&D. In addition, since one of the explanatory variables is an indicator for whether or not the firm has a history of FDI, it is possible to address the effects on R&D of India's regulations on FDI. Finally, pools of domestic and international spillover R&D are included as explanatory variables, permitting an examination of some of the effects of a weak patent regime.

Using the estimates obtained here and the ex post, production function estimates from the related work of Basant and Fikkert (1994), policy simulations are conducted which examine the effects of policy reforms on both indigenous R&D and the present discounted value of private profits. The results indicate that while the policy reforms reduce the amount of R&D conducted in India, due to the prevalence of comer solutions for the choices of R&D and TP, the fall in R&D is very low. At the same time, the fact that TP appears to have a much higher private return than R&D implies that abandoning the closed technology policy and allowing more TP will yield substantial gains in the present discounted value of profits. To be specific, the simulations conducted here indicate that even dramatic policy reforms would cause aggregate R&D to fall by only 13 percent, while the present discounted value of profits would rise by 93 percent of firms' annual profits. In other words, there appears to be little "self-reliance" lost and large productivity gains from the policy reforms currently being pursued in India.

An Open or Closed Technology Policy?

The Effects of Technology Licenses, Foreign Direct Investment, and Domestic and International Spillovers on R&D in Indian Firms

by

Brian Fikkert
University of Maryland
Department of Economics
3105 Tydings Hall
College Park, MD. 20742

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I. Introduction

Achieving technological self-reliance in the industrial sector has been a chief objective of India since its independence. To varying degrees over the past three decades, the government of India has pursued this goal through a "closed" technology policy designed to shield Indian firms from foreign influences. It was hoped that by limiting access to foreign technology, Indian firms would learn to generate innovations on their own and would in this sense be technologically self-reliant. The three key features of this closed technology policy were: 1) the adoption of a relatively weak patent regime, 2) the limitation of foreign direct investment (FDI), and 3) the regulation of technology purchase (TP) licenses to varying degrees across different industries. While India's closed technology policy has been particularly restrictive, India is by no means alone amongst less developed countries (LDCs) in utilizing a closed technology policy. Members of the Andean Pact enacted similar policies in the 1970s, and no less a technological force than Korea pursued, albeit to a lesser degree, all three aspects of India's closed technology policy.

As part of its current economic reform package, India has relaxed its restrictions on FDI and TP licenses, and stronger patent protection may be on the horizon following the agreement reached at the Uruguay Round. Of concern to many Indian policymakers is whether these regime changes will inhibit the development of an indigenous innovative capability, sacrificing long-run self-reliance in exchange for dubious short-run benefits. Such issues are also of increasing interest to academic economists concerned with the role of international technological diffusion and indigenous innovative efforts in the process of long-run growth (see Coe and Helpman (1993), Grossman and Helpman (1991), and Romer (1990)).

Unfortunately, there is very little evidence as to whether or not any feature of India's closed technology policy promotes or hinders indigenous innovative efforts in LDCs, so there is little basis on which to settle the current policy debate. With regards to the first two policies, there does not appear to be any systematic empirical evidence on the effects of weak patent regimes or FDI on LDC firms' innovative efforts. With regards to the third policy, there are a number of empirical studies purporting to show that foreign TP stimulates domestic R&D, the usual measure of innovative efforts. However, this TP literature appears to be flawed at both the conceptual and empirical levels.

At the conccptwl level, the TP literature has cited the findings of numerous case studies[1] that foreign technology--particularly that which is embodied in purchased inputs--provides a stimulus to local R&D because of the need to adapt foreign technology to local conditions. While there is undoubtedly a need to perform such adaptive R&D, there are at least two other factors which may cause TP licenses to substitute for firms' R&D expenditures. First, in contrast to the embodied technology which the firm implicitly purchases when it imports production inputs, the technology purchased through TP licenses is disembodied and supplies the firm with explicit instructions detailing the basic design and know-how for implementing some new technology. Hence, a firm which purchases technology through a TP contract does not have to perform R&D to develop this basic design and know-how on its own. Second, the costs of total expenditure on innovation--the sum of R&D and TP expenditures--may rise with the level of such expenditures due to either internal costs of adjustment to new technology or to increasing financing costs. If this is the case, then each rupee spent on TP raises the shadow price of R&D, tending to lower the quantity of R&D demanded. Indeed, a careful reading of the case study

[1]See, for example, the case studies by Bhagwati and Srinivasan (1975); Desai (1980), (1984); NCAER (1971); and Lall (1987).

literature reveals that both of these factors were observed in Indian firms,[2] at least partially offsetting the positive stimulus to R&D created by the need to adapt foreign technology to local conditions.

Citing the case-study evidence about the adaptive nature of domestic R&D, several empirical studies have found that foreign TP appears to stimulate domestic R&D expenditures. However, these studies suffer from several shortcomings. First of all, with the exception of Deolalikar and Evenson (1989), all of the existing studies of which we are aware treat either R&D or TP expenditures as an exogenous variable, subjecting the estimates to the problem of simultaneity and preventing any conclusions to be drawn about the true relationship between these two variables (Braga and Wilmore (1991); Katrak (1985), (1989), (1990), (1991); Kumar (1987); Mohnen and Lepine (1987)). Furthermore, because most firms in India choose to perform no R&D and/or to buy no technology, the firms used in such studies are frequently chosen because they are known to engage in such activities (Katrak (1985), (1989), (1990), (1991)), raising the problem of endogenous sampling and providing an additional source of bias.

Deolalikar and Evenson (1989) recognize the problem of simultaneity, estimating a two-equation, demand system in which both Indian innovative efforts and foreign TP are endogenous variables; however, because they do not have separate prices for R&D and TP, they fail to identify how these two variables interact. Furthermore, their use of industry-level data is problematic because aggregation may mask relationships at the firm level.

Employing panel data from 571 Indian firms for the period 1975-76 to 1978-79,[3] the

[2] See Fikkert (1994) for details.

[3] During this period, all three features of India's closed technology policy were in place.

present study attempts to shed some light on the effects on R&D of all three features of India's closed technology policy. We estimate a model in which both R&D and TP are choice variables for which comer solutions are possible, avoiding both the problems of simultaneity and censoring. A combination of exclusionary restrictions, cross-equation parameter restrictions, and the nonlinear manner in which TP and R&D enter into each other's equations are sufficient to identify the parameters of the model. Maximum likelihood estimation is employed to address the comer solutions, and gaussian quadrature is utilized in order to numerically integrate over the firms' unobserved, heterogeneous effects. Because both R&D and TP are treated as endogenous variables, we are able to properly address the effects of India's regulations on TP licenses. In addition, since one of the explanatory variables in both equations is an indicator for whether or not the firm has a history of foreign equity participation, we are able to address the effects of India's regulations on FDI on R&D. Finally, we include pools of domestic and international spillover R&D as explanatory variables, allowing us to shed some light on the effects of a weak patent regime.

The results indicate that, contrary to previous findings, foreign TP substitutes for R&D expenditures. In this light, India's restrictions on TP licenses appear to have provided the government's desired stimulus to indigenous R&D. However, policy simulations are provided which demonstrate that due to the prevalence of comer solutions, the overall stimulus to domestic R&D was quite small. The estimates also indicate that foreign equity participation actually raises a firm's R&D in some cases, implying that India's limits on FDI actually lowered R&D in certain industries. However, once again simulations demonstrate that the effects are very small. Finally, both foreign and domestic R&D spillovers appear to provide a positive stimulus to each firm's R&D, presumably because they provide opportunities for reverse engineering and follow-on improvements. The positive effect of the spillovers seems to suggest that a weak regime, which permits copying of the R&D of others, promotes indigenous R&D; however, there are two important caveats which must be noted. First, the positive effect of spillovers is mitigated somewhat by the usual negative impact on R&D of imperfect appropriability. In this light, the most effective patent regime for promoting indigenous R&D may be one which provides weak patent protection for foreigners and strong protection for Indians. Such a policy would permit foreign spillovers to stimulate domestic R&D and remove the negative impact of imperfect appropriability. Second, while the estimates here suggest that spillovers promote R&D, it is actually not clear whether a weak patent regime promotes or reduces international spillovers. For example, a stronger patent regime should increase foreign firms' activity on Indian soil, possibly demonstrating to Indian producers more about foreign technology and thereby increasing the total quantity of spillovers from that foreign technology. However, there is very little empirical evidence about the magnitude of such demonstration effects.

Of course, even if certain features of India's closed technology policy stimulated domestic R&D, this does not imply that a closed technology policy is desirable. Indeed, using the production function estimates of Basant and Fikkert (1994) in conjunction with the estimates obtained here, policy simulations will be provided which indicate that the private costs of the closed technology policy were substantial in India. The close of this paper will discuss the welfare implications of India's technology policies in light of the results of these policy simulations.

The rest of the paper is organized as follows. Section II presents the model and the likelihood function to be estimated. Section III describes the data and the construction of the variables. Section IV presents the estimation results. Section V uses the estimates to conduct policy simulations of the effects of various policy changes on R&D, TP, and profits. Finally, Section VI concludes the paper with a discussion of the welfare implications of these estimates.

II. Model and Construction of Likelihood Function

A crucial factor determining whether to invest in a new technology--either through R&D or TP--is obviously the number of units of output which can be produced and sold using that technology. In India, this number was largely determined by government regulations on industrial investment and the rationing of scarce inputs. As part of its overall strategy of economic planning, the Indian government declared in the Industries Act of 1951 that every investor over a very small size had to obtain a license before establishing an industrial plant, adding a new product line to an existing plant, substantially expanding the firm's capital stock, or changing the plant's location. When a license was approved, the firm was then assigned a "licensed capacity," i.e. the number of units of production which the firm was permitted to produce, and the size of the capital investment "commensurate" with that licensed capacity. Furthermore, the government rationed both foreign exchange needed to import intermediate inputs and scarce domestic resources on the basis of a firm's licensed capacity and the priority given to its industry (Bhagwati and Desai (1970)). Hence, much of a firm's input base was determined by government policy. In 1966 India's laws were changed somewhat to allow firms to increase output up to 25 percent more than their licensed capacities without getting a new license as long as the increased production did not require any additional foreign exchange, use any more scarce domestic materials, or involve more than minor additional domestic equipment (Agrawal (1975); Hazari (1986)). In effect, if productivity gains enabled a firm to increase its output without expanding its level of input use, the firm could increase its output 25 percent beyond that specified in its initial production license.

While space does not permit a complete description of the effects of these policies, it is important to note that India's regulations imposed binding constraints on long-term expansion and in many cases on short-run production goals. In the short-run, shortages of foreign exchange, scarce domestic inputs, and electricity often led to underutilization of existing capital stocks (Agrawal(l975); Bhagwati and Desai (1970); Lall (1987)). In the long-run, firms were very uncertain whether the government would grant them licenses to expand their capacities, severely reducing their incentives to introduce new products. For example, Bajaj Auto, which made the most popular motorized scooters in India, was constrained by the government to produce only 173,020 units even though there was a ten-year waiting list for its scooters. After eight years delay, Bajaj was finally permitted to expand production to 250,000 units and was hoping for an additional license to increase production to 650,000 units (Lall (1987)).

In view of these policy considerations, we assume that output for firm i in period t, Y_{it}, is given by:

$$Y_{it} = A(K_{it})F(X(L_{it})) \tag{1}$$

where A(-) is productivity as a function of firm i's knowledge at time t, K_{it}, and X is the input bundle allocated by the government as a function of the firm's licensed capacity at time t, L_{it}. Unfortunately, a firm's licensed capacity is unobserved in the data; however, as discussed earlier, in each industry the government assigned to the firm a capital stock, C_{it}, which was "commensurate" with the firm's licensed capacity. We assume that this mapping between the firm's licensed capacity and its capital stock was linear, so we can write $L_{it} = b_j C_{it}$ where b_j is the proportionality constant for industry j. Next, we make a linear approximation to F, writing it as $F = d_j L_{it}$. Finally, we assume that the price which the firm receives depends on its knowledge stock, $P(K_{it})$.

Using all of these expressions and equation (1), the firm's sales at time t are:

$$Sales_{it} = P(K_{it})A(K_{it})w_jC_{it} = G(K_{it})w_jC_{it} \tag{2}$$

where $w_j = b_jd_j$. Defining $G(K) = mK$, we get the final expression for sales at time t:

$$Sales_{it} = K_{it}(v_jC_{it}) \tag{3}$$

where $v_j = mw_j$.[4]

Now there are three basic ways for a firm to acquire new technology, thereby raising K_{it}: 1) invent the new technology on its own through R&D; 2) purchase the new technology through TP licenses; or 3) pirate the new technology from foreign or domestic spillovers. Hence, we assume that the increment to knowledge in period t, I_t, can bc cxpressed as:

$$I_{it} = a_R\bar{R}_{it} + a_{RM}\bar{R}_{it}M_i + a_T\bar{T}_{it} + a_{TM}\bar{T}_{it}M_i + a_SS_{it} + a_{RS}\bar{R}_{it}S_{it} + a_{TS}\bar{T}_{it}S_{it} + a_{RT}\bar{R}_{it}\bar{T}_{it} \tag{4}$$

where $\bar{R}_{it}$ is the real "quantity" of R&D employed at time t; $\bar{T}_{it}$ is the real "quantity" of technology purchased at time t; S_{it} is a 3x1 vector of international and domestic research pools of both the Spillover and Embodied types[5]; and M_i is a dummy taking on the value of 1 if the

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[4]An equivalent approach would be to assume that the production function for F(X) implies a fixed F(X) to C ratio. For an example of the use of this approach to the Indian licensing policies see Narayana, Parikh, and Srinivasan (1991).

[5]As discussed further below, there are three elements to S_{it}: 1) Foreign Spillover Pools (SF), 2) Domestic Spillover Pools (SD), and 3) Foreign Embodied Pools (EF).

firm ever had foreign equity participation and 0 otherwise.

Notice that there are different coefficients of productivity for $\overline{\mathbf{R}}$ and $\overline{\mathbf{T}}$ for firms with histories of foreign ownership (a, and a,,,,). Note also that a, and a, are 1x3 vectors of parameters. The firm's total stock of knowledge at time t is then determined as:

$$K_{it}=\sum_{n=0}^{\infty}(1-\delta)^{n}I_{it-n} \tag{5}$$

where δ is the decay rate of knowledge due to obsolescence.

The basic problem confronting an Indian firm is to choose an optimal amount of R&D and TP in the presence of international and domestic spillovers in order to maximize the present discounted value of the stream of future profits. Due to the prevalence of comer solutions for both R&D and TP expenditures, this is not a garden variety dynamic optimization problem, and we have invoked a special assumption in equations (4)-(5) to make the problem tractable, namely that the increments to knowledge in any given period are time separable.[6] Now at time t = 0, firm i chooses a stream of $\overline{\mathbf{R}}_{it}$ and $\overline{\mathbf{T}}_{it}$ for all t, subject to $\overline{\mathbf{R}}_{it} >= 0$ and $\overline{\mathbf{T}}_{it} >= 0$, to solve the following problem:

$$MAX\ \Pi^{i} = E_0[\sum_{t=0}^{\infty}\beta^{t}\ (\text{Sales}_{,,} - p_R\overline{R_{it}} - p_T\overline{T_{it}} - g_{it}\overline{T_{it}} - f_{it}(X_{it}))] \tag{6}$$

where Sales,, is equal to $\mathbf{K}_{it}\mathbf{v}_j\mathbf{C}_{it}$; $\mathbf{p}_R$ is the price of $\overline{\mathbf{R}}$; $\mathbf{p}_T$ is the price of $\overline{\mathbf{T}}$; $\mathbf{g}_{it}$ is the search and transactions costs per unit of $\overline{\mathbf{T}}$; $\mathbf{X}_{it}$ is the total expenditures on innovation: $\gamma_R\overline{\mathbf{R}}_{it} + \gamma_T\overline{\mathbf{T}}_{it}$; and $\mathbf{f}_{it}(\mathbf{X}_{it})$ represents the quadratically increasing costs of total expenditures on innovation: $\lambda_{it}\mathbf{X}_{it}$ +

[6]Schankerman and Nadiri (I 984) invoke a similar assumption in their empirical work, and Spence (1984) utilizes this assumption in his theoretical investigation of the effects of spillovers on R&D.

$\lambda_2 X_{it}^2$.[7]

Notice that there are three types of costs in this specification. First are the explicit costs of R&D and TP expenditures, $p_R\overline{R}_{it}$ and $p_T\overline{T}_{it}$. Second are the search and transactions costs of purchasing technology, g_{it}. Third, it is assumed that the costs of total expenditures on innovation, X_{it}, are rising quadratically, $f_{it}(X_{it})$, due to internal adjustment costs or to increasing costs of financing such investments.

g_{it} is crucial to the entire analysis. Because the intensity of the government's restrictions on TP licenses varied across industries, we can use g_{it} to identify our system of equations for R&D and TP. We assume that g_{it} takes on the following form:

$$g_{it} = \alpha_M M_i + \alpha_{MC} M_i v_j C_{it} + LR_{ijt} + \epsilon_{it} \tag{7}$$

In other words, g_{it} is a function of the firm's contacts with foreign firms as evidenced by its history of foreign equity participation,[8] the strength of the government's technology licensing restrictions for firm i in industry j at time t, LR_{ijt}, and a random shock to firm i at time t, ϵ_{it}. In the estimations which follow, we proxy LR_{ijt} in two different ways. For estimations performed on the complete sample of firms, we define:

[7]The vast majority of the empirical literature on the choice of R&D uses a cost function approach and derives the demand for R&D as a function of output (see Deolalikar and Evenson (1989); Bernstein (1988); Bernstein and Nadiri (1989); Mohnen and Lepine (1991); Mohnen, Nadiri, and Prucha (1986); and Schankerman and Nadiri (1984)). The problem with this approach is that output is a function of R&D and should really be endogenized. While the present approach has its problems, it uses the realities of the Indian capacity licensing system to overcome some of the deficiencies of the cost function approach.

[8]A review of technology licensing contracts in India during this period revealed that firms frequently purchased technology from the foreign firm which had or which previously had had some equity participation in the Indian firm. Apparently, the historical ties between the foreign and Indian firms worked to reduce the search and transactions costs for purchasing technology, so M should have a negative impact on g_{it} and a positive effect on T.

$$LR_{ijt} = \theta_A AGLIC_j + \theta_{AC} AGLIC_j{}^* v_j C_{it} \quad (8)$$

where $AGLIC_j$ is the average for the period 1975/76-1978/79 of industry j's share of total TP licenses granted by the Indian government divided by industry j's share of total manufacturing value added. Because the aggregate number of licenses granted to the industry cannot be changed dramatically by one firm, we assume this number to be exogenous to the individual firm and a measure of the government's attitude vis-a-vis TP licenses in industry j . We also estimated the model for "scientific" and "nonscientific" subsamples of firms, the former consisting of firms in the more technologically-dynamic industries of chemicals, drugs, and electronics and the latter consisting of all other types of firms.[9] Because there was not sufficient variation in $AGLIC_j$ within the separate subsamples, in the subsample estimations LR_{ijt} was proxied by:

$$LR_{ijt} = \sum_{j=1}^{N} \theta_j Z_j \quad (9)$$

where Z_j is a dummy variable taking on the value of 1 if firm i is in industry j and 0 otherwise.

Note that there are two stochastic parameters in the firm's maximization problem: g_{it} and λ_{it}. In other words, we are allowing for shocks to firms' search and transactions costs for TP and to firms' adjustment costs to new technology. It is assumed that firm i observes the values of these parameters at time t before choosing $\overline{R}_{it}$ and $\overline{T}_{it}$.

Finally, it is assumed that firms' expectations of C_{it} are determined by:

$$E_0[C_{it}] = \psi^t C_{i0} \quad (10)$$

Taking the derivative of equation (6) with respect to $\overline{R}_{i0}$, setting it equal to zero, and

[9] See Griliches and Mairesse (1984) for a similar grouping.

solving for $\overline{R}_{i0}$ gives the optimal value of $\overline{R}_{i0}$ if an interior solution is chosen:

$$R_{10} = [b_R + b_{RM}M_1 + b_{RS}S_{10} + b_T^R T_{10}]\, v_j C_{10} - b_1 - \sqrt{\frac{b_T^R}{b_R^T} T_{10}} - \lambda_{1t}^R \tag{11}$$

where

$$b_R = \phi\frac{a_R p_R}{2\lambda_2\gamma_R^2} \qquad b_{RM} = \phi\frac{a_{RM} p_R}{2\lambda_2\gamma_R^2} \qquad b_{RS} = \phi\frac{a_{RS} p_R}{2\lambda_2\gamma_R^2}$$

$$b_T^R = \phi\frac{a_{RT} p_R}{2\lambda_2\gamma_R^2 p_T} \qquad b_1 = \frac{p_R^2}{2\lambda_2\gamma_R^2} \qquad \lambda_{1t}^R = \frac{\lambda_{1t} p_R}{2\lambda_2\gamma_R} \qquad b_R^T = \phi\frac{a_{RT} p_T}{2\lambda_2\gamma_{T}^2 p_R}$$

$$R_{10} = p_R\overline{R_{10}} \qquad T_{10} = p_T\overline{T_{10}} \qquad \phi = \frac{1}{\delta(1-\psi)(1-\beta)}$$

Note that due to the assumption of time separability in the increments to knowledge, only variables at time 0 effect the choice of R_{i0}.

On the other hand, if a firm has chosen $R_{i0} = 0$, the Kuhn-Tucker *conditions* indicate that $\delta\pi/\delta R_i <= 0$ for this firm at $R_{i0} = 0$. Hence, in the case of a corner solution for R_{i0} we have the following:

$$0 \geq \left\{[b_R + b_{RM}M_1 + b_{RS}S_{10} + b_T^R T_{10}]\, v_j C_{10} - b_1 - \sqrt{\frac{b_T^R}{b_R^T} T_{10}} - \lambda_{1t}^R\right\} \tag{12}$$

Notice that the right sides of equations (11) and **(12)**, which will be denoted by the variable R_{i0}^*, are identical, enabling us to write:

$$R_{it} = R^*_{it} \text{ iff } R^*_{it} > 0 \qquad (13)$$
$$\qquad 0 \text{ iff } R^*_{it} \leq 0$$

Proceeding in precisely the same fashion for the choice of $\mathbf{T_{i0}}$, gives the following expressions:

$$T^*_{i0} = \left\{ [b_T + b_{TM}M_i + b_{TS}S_{i0} + b^T_R R_{i0}]\, v_j C_{i0} - b_2 - \sqrt{\frac{b^T_R}{b^R_T}} R_{i0} - g_i' - \lambda^T_{it} - \epsilon'_{it} \right\} \qquad (14)$$

where

$$b_T = \phi \frac{a_T p_T}{2\lambda_2 \gamma^2_T} \qquad b_{TM} = \phi \frac{a_{TM} p_T}{2\lambda_2 \gamma^2_T} \qquad b_{TS} = \phi \frac{a_{TS} p_T}{2\lambda_2 \gamma^2_T}$$

$$b_2 = \frac{p^2_T}{2\lambda_2 \gamma^2_T} \qquad \lambda^T_{it} = \frac{\lambda_{it} p_T}{2\lambda_2 \gamma_T} \qquad g_i' = \frac{(g_{it} - \epsilon_{it}) p_T}{2\lambda_2 \gamma^2_T} \qquad \epsilon_{it}' = \frac{\epsilon_{it} p_T}{2\lambda_2 \gamma^2_T}$$

and

$$T_{it} = T^*_{it} \text{ iff } T^*_{it} > 0$$
$$\qquad 0 \text{ iff } T^*_{it} \leq 0 \qquad (15)$$

Equations (11)-(15) give us a system of two equations in the two endogenous variables, $\mathbf{R_{i0}^*}$ and $\mathbf{T_{i0}^*}$, variables which are only observed when they are greater than zero. This **system** is somewhat unusual because the endogenous variables only enter into each other's equations when they are positive, as evidenced by the fact that $\mathbf{R_{i0}}$ rather than $\mathbf{R_{i0}^*}$ enters the equation for $\mathbf{T_{i0}^*}$, and vice versa for $\mathbf{T_{i0}}$ in the equation for $\mathbf{R_{i0}^*}$.

There are three factors which enable us to identify the parameters on R and T in these equations. First, there is an exclusionary restriction in that the equation for $\mathbf{T^*}$ contains a variable not found in the equation for $\mathbf{R^*}$, namely $\mathbf{g_{it}}$. Second, notice from equation (11) that $\mathbf{T}$

enters the equation for R^* in two places: linearly and interactively with the variable v_jC. The same is true for R in the equation for T^* in equation (14). The interaction of R and T with v_jC provides a nonlinearity which helps to identify the system. Finally, there are cross-equation restrictions in that the fraction multiplying the linear term of T in the R^* equation, $\sqrt{b_T^R}/\sqrt{b_R^T}$, is the inverse of the coefficient on R in the T^* equation, $\sqrt{b_R^T}/\sqrt{b_T^R}$, and the squares of the numerators and denominators of these fractions also appear as coefficients on the interactive terms of R and T with v_jC. It is possible to show that these three factors--the exclusionary restrictions, the nonlinearities, and the cross-equation restrictions--are sufficient to identify the b_T^R and b_R^T coefficients.

In order to estimate the R^* and T^* equations, it is necessary to invoke some assumptions about the error terms in these equations. Recall that the two stochastic elements observed by the firms but unobserved by the econometrician are ϵ_{it}, which is the error term from the g_{it} equation, and λ_{it}, which is the coefficient on the linear term of the adjustment cost function, f_{it}. It is assumed that ϵ_{it} and λ_{it} can be written as:

$$\epsilon_{it} = u_i^g + e_{it}^g \qquad \lambda_{it} = u_i^\lambda + e_{it}^\lambda \tag{16}$$

where u_i^g and e_{it}^g are assumed to be independent of one another, u_i^λ and e_{it}^λ are assumed to be independent of one another, and e_{it}^g and e_{it}^λ, while correlated with each other, are assumed to be independent across i and t. Finally, in order to simplify the estimation procedure, it is assumed that the two persistent error terms in equation (16) are scalar multiples of one another:

$$u_i^g = \kappa u_i^\lambda \tag{17}$$

Hence, the estimating equations reduce to:

$$R_{i0}^{*} = \left\{ [b_R + b_{RM}M_i + b_{RS}S_{i0} + b_T^R T_{i0}]\, v_j C_{i0} - b_1 - \sqrt{\frac{b_T^R}{b_R^T} T_{i0}} + \eta_i + e_{it}^R \right\} \quad (18)$$

$$T_{i0}^{*} = \left\{ [b_T + b_{TM}M_i + b_{TS}S_{i0} + b_R^T R_{i0}]\, v_j C_{i0} - b_2 - \sqrt{\frac{b_R^T}{b_T^R} R_{i0}} - g_i' + \omega_T \eta_i + e_{it}^T \right\} \quad (19)$$

$$\eta_i = \frac{-u_i^x p_R}{2\lambda_2 \gamma_R} \qquad e_{it}^R = \frac{-e_{it}^x p_R}{2\lambda_2 \gamma_R} \qquad \omega_T = \frac{\gamma_R p_T (\gamma_T + \kappa)}{(p_R \gamma_T^2)} \qquad e_{it}^T = \frac{-p_T}{2\lambda_2 \gamma_T}\left(e_{it}^x + \frac{1}{\gamma_T} e_{it}^g\right)$$

The assumed distributions of the error terms are:

$$\begin{bmatrix} e_{it}^R \\ e_{it}^T \end{bmatrix} \sim N\left(\begin{bmatrix} \mu_R + \sum_{t=1}^{3} D_t^R \\ \mu_T + \sum_{t=1}^{3} D_t^T \end{bmatrix} ; \begin{bmatrix} \sigma_R^2 & \sigma_{RT} \\ \sigma_{RT} & \sigma_T^2 \end{bmatrix} \right) \qquad \eta_i \sim N(\mu_\eta, \sigma_\eta^2)$$

$$\sigma_R = \exp(d_{0R} + d_{1R} v_j C_{it}) \quad \sigma_T = \exp(d_{0T} + d_{1T} v_j C_{it}) \quad \sigma_\eta = \exp(d_{0\eta} + d_{1\eta} v_j \overline{C_i})$$

where $\overline{C}_i$ is the mean of C_{it} over all t for firm i, and D_t^R and D_t^T are time dummies which allow the means of e_{it}^R and e_{it}^T to vary across time. By our previous assumptions, η_i is independent of e_{it}^R and e_{it}^T. In order to simplify the remaining discussion, we suppress all of the terms in equations (18)-(19) which do not involve T or R, and we simplify the coefficient on R in the T equation by β_R and the coefficient on T in the R equation by β_T.

It can be shown that the likelihood of observing R_i and T_i, the vectors of R_{it} and T_{it} for all t for firm i, conditional on η_i, is given by:

$\Pr(R_i, T_i \mid \eta_i) =$

$$\left| \begin{array}{l} \prod_1 (1 - \beta_R\beta_T)\, f(e^R_{it}, e^T_{it}) \; x \\ \prod_2 \int_{-\infty}^{-\beta_T R_{it} - \omega_T \eta_i} f(e^R_{it}, e^T_{it})\, de^T_{it} \; x \\ \prod_3 \int_{-\infty}^{-\beta_R T_{it} - \eta_i} f(e^R_{it}, e^T_{it})\, de^R_{it} \; x \\ \prod_4 \int_{-\infty}^{-\beta_T R_{it} - \omega_T \eta_i} \int_{-\infty}^{-\beta_R T_{it} - \eta_i} f(e^R_{it}, e^T_{it})\, de^R_{it} de^T_{it} \end{array} \right| \tag{20}$$

where $\prod_n$ denotes the product over all of the observations for firm i which fall into case **n** **(n=1,2,3,4)** with **n** equal to 1 denoting the case in which $R_{it} > 0$ and $T_{it} > 0$, **n** equal to 2 denoting the case in which $R_{it} > 0$ and $T_{it} = 0$, n equal to 3 denoting the case in which $R_{it} = 0$ and $T_{it} > 0$, and **n** equal to 4 denoting the case in which $R_{it} = 0$ and $T_{it} = 0$.[10]

The likelihood contribution of each firm, unconditional on η_i, is then obtained by integrating $\Pr(R_i, T_i \mid \eta_i)$ in equation (20) over the density of η_i, which is denoted by $g_\eta(\cdot)$, and then multiplying the contributions of all the firms together to give us the final likelihood function:

$$\mathcal{L}(R, T) = \prod_{i=1}^{N} \left[\int_{-\infty}^{\infty} PR(R_i, T_i \mid \eta_i)\, g_\eta(\eta_i)\, \partial\eta_i \right] \tag{21}$$

The last expression is the one estimated here. Because we assumed that η_i is distributed normally, suitable transformations allow us to apply **gaussian** quadrature to evaluate the integral

[10] See Fikkert (1994) for details.

in the last equation.

III. Data Description and Variable Summary

The firm-level data utilized in this analysis come from the annual reports of Indian public limited firms, defined as private corporations with more than 50 shareholders. Two groups of firms were included in the data set received by the author. The first group of firms were taken from the universe of public limited firms with more than 500,000 rupees of nominal, paid-up capital in 1975. The second group of firms were taken from the universe of public limited firms with more than 10 million rupees of nominal, paid-up capital in 1984. As such, these firms represent some of the largest companies in the corporate manufacturing sector in India.” There are a total of 2284 observations on 571 firms, with 206 firms (824 observations) coming from the “scientific” industries of chemicals, drugs, and electronics and 365 firms (1460 observations) coming from the “non-scientific” industries including non-electrical machinery, transportation, non-metallic minerals, paper, sugar, rubber, metals, and textiles sectors.

The individual firms’ R&D and TP expenditures were inflated to constant 1980 Rupees using the GNP deflator. As mentioned previously, one of the most salient features of the firm-level data is the number of comer solutions for the choice of R&D and TP. This is detailed in Table 1, which illustrates that roughly 90 percent of the annual observations in the firm-level data indicate choices not to perform R&D, not to purchase technology, or not to do either. It is clear that to sample only those firms which are known to be at interior solutions, as several previous studies have done, misses the most prevalent feature of the data.

“See Fikkert (1994) for a further description of this data set.

Table 1

NUMBERS OF FIRMS ACROSS R&D AND TP CASES
Percentages in Parentheses

CASES	ALL FIRMS	SCIENTIFIC FIRMS	NONSCIENTIFIC FIRMS
Case 1: R > 0, T > 0	199 (8.7)	84 (10.2)	115 (7.9)
Case 2: R > 0, T = 0	619 (27.1)	313 (38.0)	306 (21.0)
Case 3: R = 0, T > 0	216 (9.5)	74 (9.0)	142 (9.7)
Case 4: R = 0, T = 0	1250 (54.7)	333 (42.8)	897 (61.4)
Totals	2284 (100.0)	824 (100.0)	1460 (100.0)

As detailed in the previous section, this paper recognizes that corner solutions are optimal for the firms which choose them and employs econometric methodology which explicitly takes this into account. Unfortunately, the prevalence of corner solutions has also forced us to invoke the simplifying assumption that increments to knowledge are time-separable on au annual basis. The danger of this assumption is that if TP and R&D choices this year influence the choices of these variables next year, the model will fail to capture such effects. The most worrisome scenario in terms of getting the signs of the effects right is one in which the firm is at a comer solution for one of the choices this year and moves to the other comer in the following year. This would be the case, for example, if the firm purchased technology this year and then spent innovative resources on performing adaptive R&D next year.[12] In such a case, TP and R&D would be complements in production, but because these expenditures took place a year apart they would appear as substitutes in the estimating framework used here. Fortunately, this most severe case never happens in the data.

[12] There is evidence in Lall (1987) that conducting R&D in order to adapt foreign technology takes place immediately when the technology is transferred. Hence, we would expect any adaptive R&D to be conducted contemporaneously with the technology purchases.

Consider Table 2 which provides the empirical Markov transition probabilities observed in the sample, i.e. the probabilities of moving to case i given that the firm is in case j for i = l-4 and j = l-4. The transitions which would severely invalidate this paper's approach are moves from Case 2 to Case 3 and vice-versa. Notice that the empirical probabilities of such transitions are 0 for all three groups of firms. Notice also the very high probabilities along the diagonals, indicating that firms tend to remain in the same case from period to period; hence, the present approach which relies heavily on within-period data, does not appear to be missing a great deal of information about inter-period movement between the cases.

Table 2

EMPIRICAL MARKOV TRANSITION PROBABILITIES

Initial State	New State	CASE 1	CASE 2	CASE 3	CASE 4
CASE 1:	Complete Sample	0.69	0.29	0.02	0.00
	Scientific	0.70	0.30	0.00	0.00
	Nonscientific	0.68	0.28	0.04	0.00
CASE 2:	Complete Sample	0.06	0.89	0.00	0.05
	Scientific	0.04	0.91	0.00	0.03
	Nonscientific	0.07	0.88	0.06	0.05
CASE 3:	Complete Sample	0.11	0.00	0.64	0.25
	Scientific	0.07	0.00	0.67	0.27
	Nonscientific	0.14	0.00	0.62	0.24
CASE 4:	Complete Sample	0.01	0.06	0.03	0.90
	Scientific	0.02	0.11	0.08	0.79
	Nonscientific	0.00	0.04	0.01	0.94

CASE 1: $R > 0, T > 0$, CASE 3: $R = 0, T > 0$;
CASE 2: $R > 0, T = 0$, CASE 4: $R = 0, T = 0$;

The historical ownership patterns of the firms in this study were examined using Kothari's Economic and Industrial Guide for various years. The information is not very detailed, so it is not possible to determine percentages of foreign ownership but only whether there is some history of foreign shareholding, as indicated by the variable **M** in the previous section. It should be pointed **out that due to government regulations, most firms were forced to dilute their** percentages of foreign-held shares in 1974 to less than 40 percent, so even the firms with a history of FDI were majority-owned by Indians during the period examined here.

Each firm's gross, nominal capital stock was changed into a net, constant-rupee capital stock, C_{it}. See Fikkert (1994) for details.

The variable v_j was estimated by taking an average of industry j's output to capital ratio for 1972-1974, the three years prior to the start of the firm-level data, using the figures reported in Annual Survev of Industries: Factory Sector. There is a slight problem with this procedure since the industry output is a function of the average level of knowledge, K, in the industry; however, as long as there is very little specialized knowledge in India, a reasonable assumption at this early stage in India's technological development, the average **K** can be considered public knowledge and simply absorbed into v_j.

$AGLIC_j$, a proxy for the strength of the government's TP regulations in industry j, is the average for the period 1975/76-1978/79 of industry j's share of total TP licenses granted by the Indian government divided by industry j's share of total manufacturing value added.[13] The number of TP licenses by industry were obtained from Directory of Foreign Collaborations in Indian Industry, and the industrial-level value added was taken from Annual Survev of Industries: Factorv Sector.

The first element of the 3x1 spillover vector, S_{it}, is SF,, the Foreign Spillover pool consisting of the R&D conducted by the rest of the world in each firm's industry, j .[14] In

[13]My thanks to Rakesh Basant for providing me with the variable AGLIC.

[14]The "rest of the world" is proxied by 8 developed countries--Belgium, France, Japan, the Netherlands, Switzerland, United Kingdom, United States, and West Germany--for which R&D and patent data were available from an unrelated project at Yale University. The R&D data originally came from OECD data files, while the patent data was originally obtained from the patent offices of each country. These 8 countries account for the vast majority of world R&D.

creating this pool, we attempted to account for the fact that not all foreign technology is equally relevant in India by constructing spillover relevance indices, SRI_{jc}, to weight the R&D emanating from industry j in country c, R_{jct}. As described in detail in Fikkert (1994), SRI_{jc} is the ratio of the number of patents granted by India to inventors in industry j from country c to the number of patents granted by country c to inventors in industry j from country c. In other words, we are assuming that higher levels of patenting in India indicates higher levels of relevance of the technology to India. SRI_{jc} was normalized to add up to 1 within an industry. Thus, SF_{jt} is the sum over c of $SRI_{jc}R_{jct}$.

The second element of S_{it} is EF_{jt}, the Foreign Embodiment pool consisting of the R&D conducted by foreigners which is embodied in the inputs which an Indian firm in industry j typically imports from industries k, k not equal to j . Because EF_{jt} is purchased when a firm buys its inputs, it is not a spillover in the usual sense of the term. As mentioned earlier, numerous case studies have mentioned that the technology embodied in imported intermediates must be adapted to local conditions before being utilized in the Indian context. Hence, we expect EF_{jt} to provide a positive stimulus to firms' R&D expenditures. In order to construct EF_{jt}, patents granted by India to foreigners were first weighted by the R&D-patent ratio prevailing in the patents' industry of manufacture in the country from which the patent originated. The Yale Technology Concordance[15] was then used to map these R&D-weighted patents into industries which purchase the patents' technology when it is embodied in intermediate inputs, the resulting

[15]See Evenson, Kortum, and Putnam (1989) for a complete description of the Yale Technology Concordance.

embodied technology pool being denoted by E_{jct}.

The final element of S_{it} is SD_{ijt}, the Domestic Spillover pool consisting of the R&D conducted by firms other than firm i in firm i's industry, j in India. This aggregate R&D data was obtained from smoothing the R&D data reported in Research and Development Statistics, published annually by India's Department of Science and Technology. [16]

Table 3 lists the variables, and Table 4 details their means and standard deviations. Notice in Table 4 that the mean level of R&D and of its intensity, as evidenced by the ratio of R to v_jC, is higher for the scientific firms than for the nonscientific firms, as expected.

IV. Estimation Results

The maximum likelihood estimation was performed on a Sun workstation using the method of Davidon, Fletcher, and Powell (see Fletcher 1970). The estimated coefficients are detailed in Tables 5-7. Consider first the R equation. Note from equation (18) that the coefficient on T in the R equation is $\left(b_T^R v_j C - \sqrt{b_T^R} / \sqrt{b_R^T}\right)$, for which values and t-statistics are reported in Table 8 for firms in each of the four cases. In contrast to the findings of previous studies, the coefficient on T in the R equation is always significantly negative in all of the regressions, implying that anything which raises T will indirectly lower R. Notice that the coefficient is less negative in Case 1 than in the other cases. This is due to the fact that b_T^R is positive, so that $\left(b_T^R v_j C - \sqrt{b_T^R} / \sqrt{b_R^T}\right)$ is increasing in v_jC. As firms get larger, the positive effect of size on the returns to R&D and TP offsets the negative impact of the adjustment costs, making it more likely that larger firms engage in both R&D and TP. This is a clear feature of

[16]See Fikkert (1994) for details on the construction of SF, EF, and SD.

Table 3

VARIABLE NAMES AND DEFINITIONS

A. Variables Used in Knowledge Production Function

1. R — The R&D expenditures of the firm inflated to 1000s of 1980 rupees.
2. T — The technology purchase expenditures of the firm inflated to 1000s of 1980 rupees.
3. SF — The spillover pool from the world's R&D in 1000s of constant 1980 dollars.
4. SD — The spillover pool from domestic R&D in 100s of constant 1980 rupees.
5. EF — The R&D embodied in the inputs imported from the rest of the world expressed in 1000s of constant 1980 dollars.
6. M — The dummy indicator for a history of foreign equity participation.
7. v_jC — The variable representing F(--) in the production function for final output: Y = A(K)F(X(L)). C is the net capital stock of the firm expressed in billions of constant 1980 rupees. v_j is the industry level output to capital ratio. v_jC multiplies each element of the knowledge production function in the estimating equations.

B. Variables Used in the Search/Transactions Cost Function

8. M — Same as above.
9. v_jC — Same as above
10. AGLIC — The average for the period 1975/76-1978/79 of industry j's share of total TP licenses granted by the Indian government divided by industry j's share of total manufacturing value added
11. DELM — Dummy if in electrical machinery industry.
12. DOFF — Dummy if in office machines industry.
13. DCAB — Dummy if in cable industry.
14. DLIT — Dummy if in lighting industry.
15. DINS — Dummy if in [redacted] industry.
16. DCOM — Dummy if in [redacted]tions industry.
17. DDRG — Dummy if in drugs industry.
18. DCHE — Dummy if in chemicals industry.
19. DFIB — Dummy if in synthetic fibers industry.
20. DPLA — Dummy if in plastic resins industry.
21. DFER — Dummy if in chemical fertilizers industry.
22. DPAN — Dummy if in paints industry.
23. DREF — Dummy if in refrigeration industry.
24. DAGM — Dummy if in agricultural machinery industry.
25. DCAR — Dummy if in motor vehicles industry.
26. DMAC — Dummy if in nonelectrical machinery industry.
27. DCEM — Dummy if in cement industry.
28. DCLA — Dummy if in clay industry.
29. DASB — Dummy if in asbestos industry.
30. DGLA — Dummy if in glass industry.
31. DSUG — Dummy if in sugar products industry.
32. DTEX — Dummy if in textile products industry.
33. DALM — Dummy if in aluminum castings industry.
34. DSTE — Dummy if in steel castings industry.
35. DTUB — Dummy if in steel tubes and pipes industry.
36. DWIR — Dummy if in wire products industry.
37. DRUB — Dummy if in rubber products industry.
38. DPAP — Dummy if in paper industry.

C. Distributional Parameters[17]

39. d_{0R} — First term in σ_R
40. d_{1R} — Second term in σ_R
41. D_t^R — Time dummy for the mean of e_{it}^R for t = 1975/76-1977/78.
42. μ_R' — $\mu_R - b_1 + \mu_\eta$
43. d_{0T} — First term in σ_T
44. d_{1T} — Second term in σ_T
45. D_t^T — Time dummy for the mean of e_{it}^T for t = 1975/76-1977/78.
46. ω_T — Multiplier on η_i in the T equation
47. μ_T' — $\mu_T - b_2 + \omega_T\mu_\eta$
48. ρ — Correlation between e_{it}^R and e_{it}^T
49. $d_{0\eta}$ — First term in σ_η
50. $d_{1\eta}$ — Second term in σ_η

[17] Recall that we have assumed heteroscedasticity for all of the variances of the form $\sigma = \exp(d_0 + d_1 v_j C)$.

Table 4
MEANS AND STANDARD DEVIATIONS OF VARIABLES

Variable	Complete Sample Mean	Complete Sample Standard Deviation	Scientific Subsample Mean	Scientific Subsample Standard Deviation	Non-Scientific Subsample Mean	Non-Scientific Subsample Standard Deviation
R for all firms	413.6	1358.8	646.4	1782.5	282.1	1024.1
$R/(v_jC)$ for all firms	2172.4	6091.3	3977.2	8866.1	1153.8	3292.5
R for firms with $R > 0$	1154.7	2074.2	1341.7	2380.9	978.5	1720.6
$R/(v_jC)$ for firms with $R > 0$	6065.6	8946.5	8254.9	11312.2	4001.1	5122.4
T for all firms	179.0	975.1	156.8	681.8	191.5	1106.8
$T/(v_jC)$ for all firms	855.1	4623.0	723.7	2781.1	929.2	5391.1
T for firms with $T > 0$	985.1	2108.7	817.9	1375.7	1088.0	2450.0
$T/(v_jC)$ for firms with $T > 0$	4706.1	9984.4	3774.4	5381.1	5278.9	11941.1
C	.071	.113	.068	.113	.072	.113
v_j	2.63	1.08	3.04	1.45	2.40	.706
v_jC	.152	.204	.155	.226	.151	.191
SF	52.86	78.63	98.2	99.3	27.27	47.89
SD	103.2	127.7	187.3	145.9	56.54	85.68
EF	4.01	5.09	6.60	5.97	2.54	3.82
AGLIC	1.23	1.57	---- *	---- *	---- *	---- *

* This variable was not used in the subsample estimations.

Table 5

PARAMETER ESTIMATES FOR KNOWLEDGE PRODUCTION FUNCTION

VARIABLE (Associated Parameter in Parentheses)	COMPLETE SAMPLE R Equation	SCIENTIFIC FIRMS R Equation	NON-SCIENTIFIC FIRMS R Equation	VARIABLE (Associated Parameter in Parentheses)	COMPLETE SAMPLE T Equation	SCIENTIFIC FIRMS T Equation	NON-SCIENTIFIC FIRMS T Equation
T*v_jC (b_T^R)	.166 (9.42)*	.732 (8.24)*	.164 (10.17)*	R*v_jC (b_R^T)	1.01 (7.91)*	1.12 (9.10)*	2.72 (8.54)*
SF*v_jC (b_{RS1})	5.59 (1.83)**	9.42 (3.72)*	19.11 (3.11)*	SF*v_jC (b_{TS1})	10.94 (1.87)**	6.48 (3.45)*	47.39 (2.42)*
SD*v_jC (b_{RS2})	6.41 (3.39)*	3.47 (1.79)**	8.00 (2.20)**	SD*v_jC (b_{TS2})	10.75 (2.61)*	-1.44 (-0.782)	24.79 (2.04)**
EF*v_jC (b_{RS3})	268.9 (18.70)*	26.79 (16.04)*	159.3 (2.90)*	EF*v_jC (b_{TS3})	571.3 (58.62)*	13.16 (4.36)*	808.6 (6.29)*
Intercept*v_jC (b_R)	1748.3 (27.07)*	-200.6 (-13.79)*	1203.1 (20.29)*	Intercept*v_jC (b_T)	3390.7 (22.7)*	2601.2 (86.31)*	3885.8 (13.31)*
Intercept*M*v_jC (b_{RM})	2656.6 (36.31)*	352.2 (153.4)*	1276.1 (19.05)*	Intercept*M*v_jC (b_{TM})	SEE NOTE BELOW	SEE NOTE BELOW	SEE NOTE BELOW

(t-statistics are in parentheses)
* Significant at .01 level ** Significant at .05 level

Note: Because M*vC enters both the knowledge production function and the search/transactions cost function, the parameter on this variable is really the sum of two parameters. See the search/transactions cost function for the estimate of this combined parameter: $\alpha_{MC}' = \alpha_{MC}/(2\lambda_2 p_T) - b_{TM}$

Table 6

PARAMETER ESTIMATES FOR SEARCH/TRANSACTIONS COST FUNCTION

Variables for Search/Transaction Costs Complete Sample	Estimates for Search/Transaction Costs Complete Sample	Variables for Search/Transaction Costs Scientific Firms	Estimates for Search/Transaction Costs Scientific Firms	Variables for Search/Transaction Costs Nonscientific Firms	Estimates for Search/Transaction Costs Nonscientific Firms
M (α_M')	-163.3 (-4.40)'	M (α_M')	-353.5 (-8.40)'	M (α_M')	-481.2 (-5.53)*
M*v_jC (α_{MC}')	5253.5 (53.99)*	M*v_jC (α_{MC}')	-470.9 (-14.32)*	M*v_jC (α_{MC}')	-1690.1 (8.03)*
AGLIC (θ_A)	1.86 (0.14)	DOFF (θ_1')	638.3 (66.06)*	DASB (θ_{13}')	2796.2 (32.53)*
AGLIC*v_jC (θ_{AC})	-719.7 (-11.24)*	DDRG (θ_2')	965.9 (193.7)*	DTUB (θ_{14}')	3089.1 (28.55)*
		DCHE (θ_3')	939.8 (280.4)*	DWIR (θ_{15}')	2921.1 (28.89)*
		DFIB (θ_4')	1153.9 (163.2)*	DTEX (θ_{16}')	2808.8 (41.33)*
		DPLA (θ_5')	908.1 (38.9)*	DRUB (θ_{17}')	2782.0 (29.68)*
		DINS (θ_6')	1215.4 (57.4)*	DSUG (θ_{18}')	3725.7 (37.47)*
		DELM (θ_7')	617.9 (28.2)*	DALM (θ_{19}')	2896.4 (34.34)*
		DFER (θ_8')	938.8 (19.9)*	DSTE (θ_{20}')	2583.8 (23.30)*
		DCOM (θ_9')	1175.0 (100.5)*	DREF (θ_{21}')	2134.3 (23.70)*
		DCAB (θ_{10}')	1051.4 (359.3)*	DAGM (θ_{22}')	2249.2 (22.83)*
		DLIT (θ_{11}')	1464.5 (123.0)*	DMAC (θ_{23}')	2339.4 (21.87)*
		DPAN (θ_{12}')	888.6 (35.60)*	DCAR (θ_{24}')	2170.5 (20.80)*
				DCEM (θ_{25}')	3804.2 (38.82)*
				DCLA (θ_{26}')	3C68.4 (27.61).
				DGLA (θ_{27}')	2638.5 (20.81)*
				DPAP (θ_{28}')	2884.7 (29.51)*

(t-statistics are in parentheses)
* Significant at .01 level ** Significant at .05 level

Table 7

ESTIMATES OF DISTRIBUTIONAL PARAMETERS

PARAMETER	COMPLETE SAMPLE	SCIENTIFIC FIRMS	NONSCIENTIFIC FIRMS
d_{0R}	5.84 (186.4)*	5.87 (122.3)*	5.45 (99.78)*
d_{1R}	3.33 (30.92)*	4.26 (20.62)*	3.58 (21.36)*
μ_R^*	-811.1 (-29.93)*	-290.7 (-7.04)*	-709.2 (-28.95)*
D^R_{1975}	-128.9 (-4.14)*	-200.0 (-5.34)*	-61.85 (1.80)**
D^R_{1976}	-143.5 (-5.00)*	-189.8 (-4.43)*	-70.95 (-53.73)*
D^R_{1977}	-111.7 (-5.83)*	-73.54 (-2.64)*	74.99 (-2.33)*
d_{0T}	6.97 (177.5)*	6.73 (100.7)*	7.15 (127.9)*
d_{1T}	2.40 (21.16)*	1.65 (8.28)*	2.01 (11.12)**
μ_T^*	-1975.8 (-47.78)*	SEE NOTE BELOW	SEE NOTE BELOW
D^T_{1975}	-149.3 (-1.88)**	-81.28 (-6.04)*	195.3 (1.27)
D^T_{1976}	-237.3 (-3.18)*	-131.6 (-1.55)	77.14 (0.773)
D^T_{1977}	-233.9 (-6.07)*	-77.20 (-4.60)*	-124.6 (-0.860)
$d_{0\eta}$	6.94 (176.2)*	6.81 (62.25)*	6.69 (118.7)*
$d_{1\eta}$	3.55 (3.48)*	3.07 (3.09)*	5.27 (3.18)*
ω_T	2.04 (39.69)*	0.759 (8.70)*	3.16 (15.30)*
ρ	0.977 (177.3)*	0.941 (67.13)*	0.926 (61.98)*

(t-statistics are in parentheses)
* Significant at .01 level ** Significant at .05 level

Note: μ_T^* is normalized to zero in order to avoid multicollinearity with the industry dummies.

Table 8

ESTIMATED COEFFICIENT ON T IN THE R EQUATION BY CASES

	COMPLETE SAMPLE	SCIENTIFIC FIRMS	NONSCIENTIFIC FIRMS
Case 1	R = -0.347T (25.94)*	R = -0.565T (-12.08)*	R = -0.186T (-12.90)'
Case 2	R = -0.375T (-31.78)*	R = -0.709T (-12.92)'	R = -0.207T (-13.78)*
Case 3	R = -0.373T (-31.45)'	R = -0.607T (-12.48)*	R = -0.220T (-14.19)'
Case 4	R = -0.390T (-34.99)*	R = -0.7357 (-12.94)*	R = -0.230T (-14.42)'
Cases 1-4	R = -0.381T (-33.02)*	R = -0.696T (-12.90)*	R = -0.221T (-14.20)'

(Note: The coefficients and the t-statistics, which are in parentheses, are found by evaluating $(b_T^R v_j C \quad \sqrt{b_T^R / \sqrt{b_R^T}})$ and its variance at the mean value of $v_j C$ for the observations which fall in each case.)

* Significant at .01 level ** Significant at .05 level.

CASE 1: R > 0, T > 0 CASE 3: R = 0, T > 0
CASE 2: R > 0, T = 0 CASE 4: R = 0, T = 0

the data, since the mean value of v_jC for the nonscientific firms in Case 1 $(R > 0, T > 0)$ is .364 as compared with .133 for nonscientific firms in Cases 2-4. Similarly, the mean value of v_jC is .335 for the scientific firms in Case 1 as compared with .134 for the scientific firms in Cases 2-4.

The direct effect of foreign spillovers, SF, on R&D is positive and significant in all three estimations, suggesting that the spillovers act as the seed from which domestic inventions are grown. This finding is in accordance with the suggestion of Cohen and Levinthal (1989) that firms need to perform R&D in order to imitate the R&D of others. A similar conclusion maybe drawn with respect to the impact of domestic spillovers, SD, on R&D, since the coefficient on this variable is also positive and significant in all three estimations.

The impact of embodied foreign technology, EF, on R&D is significant and positive in all of the regressions. As mentioned earlier, this is in accordance with the findings of numerous case studies which have emphasized that foreign inputs need to be adapted to make them suitable to the Indian environment.

Notice that in all of the estimates, having a history of foreign equity participation provides a significant, positive, direct effect on R&D, as evidenced by the parameter b_{RM}. The model in this paper would interpret this result as indicating that firms with histories of FDI have greater productivity in performing R&D. This may very well be the case since such firms may employ scientists from their parent companies who possess considerable R&D experience. Another possible explanation is that firms with histories of FDI have access to better financing for investment than other firms, causing a positive, direct effect of FDI on R&D expenditures. Unfortunately, it is not possible to determine whether the sign of b_{RM} is due to a productivity effect or a financing effect with the present data.

At the same time, for both sets of firms, foreign shareholding has a positive and significant impact on technology purchases, the historical ties with foreign companies appearing to lower the search and transactions costs for technology licensing as evidenced by the parameters α'_M and α'_{MC}. Because R and T are substitutes for one another, this positive impact of foreign equity participation on T lowers R, partially offsetting the positive direct effect of FDI on R&D mentioned previously.

Turning to the other parameters in the T equation, the effect of SF on T is positive and significant in all three estimations. A negative coefficient might have been expected, since firms may pirate should substitute for what they must buy; however, it is likely that SF is acting as a proxy for the quantity of foreign technology available for purchasing in each firm's industry. As such, a positive relation between SF and T might be expected.

In all three of the equations, EF has a positive, significant effect on T. Since TP licenses are primarily composed of know-how for introducing new and improved products, it is not surprising that firms with greater access to the foreign inputs needed to produce such products, as evidenced by a higher EF, would be more likely to enter into licensing contracts.

For the complete set of firms, the coefficient on the interaction between AGLIC, which is our proxy for the government's TP regulations, and v_jC is significant and negative, indicating that looser TP regulations lower the search and transactions costs of purchasing technology, g, resulting in higher levels of TP, ceteris paribus. Similarly, an examination of the dummy parameters, θ_j, in the subsample estimations indicates that there is considerable inter-industry variance in the stringency of the government's technology licensing regulations, causing g to differ across the firms. For the scientific **firms** these dummy parameters range from 618 to 1465, while for the nonscientific **firms** they range from 2134 to 3804.

V. Policy Simulations

It is difficult to quantify the effects of India's policies because of the prevalence of comer solutions for firms' choices of R&D and TP. These comer solutions imply that the derivatives of R and T with respect to any policy change are different in each of the four cascs. For example, for a firm which is initially in Case 1 (R > 0, T > 0) the derivative of R with respect to the strength of the government's TP licensing regulations is:

$$\frac{\Delta R^*}{\Delta g^I} = \frac{-\left[b_T^R v_j C - \sqrt{b_T^R / b_R^T}\right]}{\left[1 - \left(b_T^R v_j C - \sqrt{b_T^R / b_R^T}\right)\left(b_R^T v_j C - \sqrt{b_R^T / b_T^R}\right)\right]}$$

This derivative is positive as long as the numerator is positive, a condition which Table 8 demonstrates to be the case for the current estimates.** However, if the firm initially has chosen a comer solution for either R or T (Cases 2-4), the derivative of R with respect to **g** is 0, implying that a change in g will only cffcct R if it is sufficicntly largc to first move the firm into Case 1. Clearly, there will be a nonlinear relationship between any policy change and its effects on aggregate R&D and TP, the elasticity of response depending heavily on the initial distribution of firms and the size of the policy change. Hence, simulations are necessary in order to get a sense of the magnitudes of various policies' impacts.

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[18]Amemiya (1974) has shown that the denominator must be positive in order for the estimates to **maximize** the likelihood function. In the present context, it is also the case that the denominator must be positive in order for firms to be at profit-maximizing choices of **R** and **T.**

The basic methodology employed in these simulations was to make random draws from the distributions of the errors terms in equations (18)-(19). Using these random draws, the estimated parameters, and the values of the exogenous variables in 1978, values of R and T were calculated according to equations (18)-(19). The government's policy parameters were then changed with respect to the technology licensing regulations, the patent protection for foreigners, and the FDI restrictions. Using the same random draws which were obtained in the previous step, new values of R and T were then computed for each firm, taking into account the effects of the change in government policy on each firm's optimal choices. For each firm we now have a flow of R and T in 1978 both before and after the change in government policy in that year. We then employed the fixed effects, production function estimates for the same firms obtained by Basant and Fikkert (1994) in order to examine the marginal effects of the policy-induced changes in R and T on the present discounted value of profits (PDV), assuming an annual discount rate of 8 percent and growth rates of both 0 and 6 percent in firms' capital, labor, and materials inputs.[19,20] The estimates of Basant and Fikkert (1994) indicate that the return to TP is much higher than to R&D, implying that any policy which causes TP to go up is likely to raise profits even if R&D expenditures go down.

One hundred rounds of each set of simulations were conducted, a new pair of independent

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[19]For both the scientific and nonscientific subsamples, Basant and Fikkert (1994) estimate a production function in which capital, labor, and materials are traditional inputs, and R&D, TP, and spillovers are knowledge inputs. Because their estimates without spillovers appear to be more reliable, we use these in the current paper, examining only the effects of different levels of R and T on output. See the fixed effects estimates with time dummies in Tables 3-4 of Basant and Fikkert (1994).

[20]The average annual growth rate in output for the firms in the data set was 6 percent for the period 1975-76 through 1979-80.

errors being drawn for each firm in each round. At the end of each round, the firms' endogenous variables (R, T, PDV) were summed to give the aggregate values of these endogenous variables. Finally, the means of these 100 aggregate, endogenous variables were computed. Because the random draws were independent of one another across rounds (and across firms), the Central Limit Theorem indicates that the mean value of any particular aggregate, endogenous variable is distributed normally, enabling us to compute t-statistics for the means.

A. Effects of Weakening the Technology Licensing Regulations

If the Indian government were to weaken its TP regulations, what would be the impact on R&D? We have already seen from the derivative in equation (24) that--for firms in Case 1 ($R > 0$, $T > 0$)--as long as the coefficient on T in the R equation is negative, i.e. R and T are substitutes, a fall in g will lower R. In fact, it is possible to show that a sufficient condition for aggregate R to drop from a fall in g is that the coefficient on T in the R equation is negative for all firms, something demonstrated in Table 8.[21]

By how much will R fall when g falls? To answer this question we simulate the effects of the Indian government's weakening of its TP licensing regulations sufficient to double the amount of firms' aggregate TP expenditures.[22] In fact, the Indian government introduced such

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[21]See Fikkert (1994) for a proof.

[22]In all of the simulations which follow, the effect of the policy change resulting from the fact that the policy alters the amount of aggregate domestic R&D and hence raises the domestic spillover pool is being ignored. In other words, $(\delta R/\delta SD)(\delta SD/\delta g)$ and $(\delta T/\delta SD)(\delta SD/\delta g)$ are not being taken into account in these simulations. Because we do not have the universe of firms, it is not possible to compute $(\delta SD/\delta g)$ with any reasonable degree of accuracy. In light of the small elasticities of R with respect to SD and the small change in aggregate R&D which results from the more direct effects of these policies, it would appear that $(\delta R/\delta SD)(\delta SD/\delta g)$

a policy in 1980, the number of technology contracts granted in the 1980s jumping to twice their pre-1980 level. Simulation 1 in Table 9 reports the means and t-statistics from such a loosening of the TP regulations. As predicted, when g is lowered, R falls, but the response of R is rather low, dropping by only 14 percent for the complete sample and by 9 percent and 17 percent for the scientific and nonscientific subsamples, respectively. However, due to the higher productivity of T than R, for the complete sample of firms the present discounted value of private profits rises by 88.36 percent in the case of 6 percent growth in other inputs (PDV6). While the numbers are similar for the scientific firms, the estimates for the nonscientific firms indicate much larger gains in percentage terms of 168.8 percent in the case of 6 percent growth.

B. Effects of Strengthening the Patent Protection for Foreigners

There are several difficulties in assessing the impacts on R&D of changing patent protection for foreigners. First, while the direct effect of international spillovers seems to stimulate firms' R&D,[23] it is not clear whether a stronger patent regime promotes or reduces aggregate foreign spillovers. As discussed earlier, if a stronger patent regime causes foreign firms to engage in more activities in India, and if such activities demonstrate more about foreign technology to Indian firms, then it is possible that a stronger patent regime will actually increase spillovers of foreign technology, promoting domestic R&D according to the estimates in this paper. Furthermore, a stronger patent regime may increase the amount of TP expenditures both because technology suppliers should be more willing to license technology which receives

and $(\delta T/\delta SD)(\delta SD/\delta g)$ are very small, so ignoring them will not substantially change the results of these simulations.

[23] See the coefficient on SF in the R equation of Table 5.

stronger protection and because Indian firms should be more willing to pay for technology which they can no longer pirate. If these effects of a stronger regime raise T, they would put downward pressure on R. Unfortunately, we are unable to capture all of these effects by simply examining the coefficient on SF in the T equation.

Because of all of these difficulties, we should be very hesitant about drawing conclusions from the estimates concerning the effects of adjusting the strength of the patent system. But for the sake of argument, let us make the standard assumption that a stronger patent regime for foreigners reduces international spillovers into India and that the indirect effects of strengthening the patent regime on R through the T equation are negligible. Then, the positive, significant coefficient on SF indicates that providing stronger patent protection for foreigners will reduce indigenous R&D.

Under these assumptions, by how much will R fall when India offers stronger patent protection to foreigners? To answer this question we must first determine the extent to which international spillovers in India would fall when India strengthens its patent protection. This is clearly very difficult to predict, but it appears that the drop in spillovers would be very small due to low levels of patenting by foreigners in India. Consider that even under the relatively strong British patent regime which prevailed in India prior to 1972, only about 3-4 percent of the patents taken out in the developed countries were taken out in India, a figure which fell to about 2 percent in the weaker, post-1972 regime. Hence, all else equal, even if India strengthened its regime to the pre-1972 levels, this would raise the amount of foreign technology patented in India from 2 to 4 percent. To be generous, let us say that a rise to 6 percent of world patents taken out in India is achievable. Now even if the protection for the inventions patented in India were perfect so that a full 6 percent of the world's inventions could not be copied by Indians, this would only represent a reduction in spillovers of 4 percent from their previous levels (6 percent under the strong regime minus 2 percent under the weak regime). Low levels of foreign patenting in India give the Indian government very little leverage for controlling the size of the international spillover pool.

The effect on R&D of a 4 percent reduction in international spillovers was simulated by lowering SF in the R equation by 4 percent. As the results from Simulation 2 in Table 9 indicate, the drop in R is less than 0.5 percent in all three sets of estimates. Because R and T are substitutes, the fall in R induces a small rise in T, causing a slight increase in the present discounted value of profits.[24]

C. Effects of Loosening the Regulations on FDI

As discussed earlier, there are two effects of FDI on R. First, there is a direct effect, captured by the term $b_{RM}v_jC$ in equation (18), which is estimated to be positive in all three sets of regressions. Second, there is an indirect effect resulting from the fact that FDI lowers the search and transactions costs of T, thereby causing R to fall because R and T are substitutes. Depending on whether the direct or indirect effect is stronger, FDI might rase R&D for some firms while lowering it for others. Indeed, this was the case for the firms in our sample.

In order to quantify the aggregate effects of introducing more FDI, simulations were

[24]Table 9 uses estimates from Basant and Fikkert (1994) which do not include international spillovers as a production input; hence, we are overlooking two effects on profits in the computations in Simulations 2 and 4: 1) When international spillovers are reduced, the marginal productivity of an Indian firms' R&D is lowered, reducing output and profits below the level computed in Table 9; 2) There is potentially a positive, direct effect of international spillovers on output (although Basant and Fikkert (1994) find such an effect to be insignificant), implying that when spillovers fall both output and profits will be lower than that computed in Table 9.

conducted in which firms initially without FDI were chosen at random to receive FDI, the probability of being chosen adjusted to cause approximately a 30 percent increase in FDI. As the results of Simulation 3 in Table 9 illustrate, introducing FDI raised R&D for the complete sample and the nonscientific subsample, but lowered it for the scientific subsample. However, the effects on R&D are very small in all three cases. For all three sets of firms, allowing greater FDI increased TP expenditures, causing slight increases in the present discounted value of profits.[25]

D. Effects of Abandoning the Closed Technology Policy

What is the overall effect of abandoning all three features of the closed technology policy simultaneously? The answer to this question obviously hinges on the extent to which each feature of the closed technology policy were changed. Hence, it is necessary to consider changes in policies which seem the most plausible in terms of their magnitude. As mentioned earlier, the Indian government relaxed its TP regulations in 1980, the result being a doubling of annual TP expenditures in the 1980s. Hence, there is historical precedent for the doubling of TP expenditures in Simulation 1. Similarly, rates of foreign patenting in India before and after the patent regime change in 1972 are known. As discussed earlier, the low levels of foreign patenting in India even under a strong regime suggest that increasing patent protection would reduce spillovers by at most 4 percent. Unfortunately, it is difficult to gauge the extent to which FDI could reasonably be expected to increase once FDI regulations were relaxed In Simulation

[25] The production function estimates in Basant and Fikkert (1994) do not examine the effects of FDI on the productivity of firms' R&D or TP, nor do they explore any direct effects of FDI on output. Hence, these simulations are only capturing the effects on output of FDI as it changes firms' levels of R&D and TP.

3, a reduction in FDI regulations sufficient to increase the number of firms with FDI histories by roughly 30 percent was considered. This seems to be a substantial increase; however, the 30 percent increase admittedly was chosen quite arbitrarily.

In light of these considerations, simulations were conducted in which the government policy parameters were held at the same levels as in Simulations 1-3. Sensitivity analysis was then conducted with respect to the percentage of FDI increase, the results indicating virtually no change from the figures for Simulation 4 in Table 9. It is clear that the abandonment of the TP regulations dominates the other two policies, the overall results being very similar to those of Simulation 1. R&D falls by 13, 11, and 16 percent for the complete sample, scientific subsample, and nonscientific subsample, respectively. This is matched by dramatic increases in the present discounted value of profits of 93, 78, and 170 percent for the complete sample, scientific subsample, and nonscientific subsample, respectively. Clearly, the private cost per unit of R&D "gained" under the closed technology policy is very high.

VI. Conclusion

Are there any conditions under which adopting any feature of India's closed technology policy would be optimal or even welfare improving? Space does not permit a detailed answer to this question, but a variety of authors have examined this issue theoretically.[26] With regards to patent protection, several papers have shown that it is frequently optimal for LDCs to provide weak patent protection for foreigners (see Chin and Grossman (1988); Diwan and Rodrik (1989); Subramanian (1991)). However, these papers all implicitly assume that there are no

[26] See Fikkert (1994) for a review of this literature.

demonstration effects from the increased working of foreign technology in the LDC, the presence of which could actually cause spillovers to increase when a patent regime is strengthened. With regards to the FDI restrictions, Fikkert (1994) shows that for the issues considered in this paper there is nothing to justify India's outright limitations on FDI. Finally, Fikkert (1994) demonstrates that whenever the social value of indigenous R&D exceeds the private value--as is the case when domestic R&D externalities are present--then a tax (subsidy) on TP is welfare-improving whenever R&D and TP are substitutes (complements). If there are also externalities from TP, then the result still holds as long as the TP externality is not too large relative to the R&D externality.

In this light, our finding that R&D and TP are substitutes and that there are domestic R&D externalities might--in principle--justify a tax on TP expenditures. However, this conclusion hinges on there being no TP externalities, an issue which could not be addressed with present data. Given our ignorance about the extent of such TP externalities, policymakers viewing these result. should he very cautious about placing a tax on TP expenditures for two primary reasons. First, as the simulations in this paper indicate, the presence of comer solutions for R&D and TP imply that the aggregate elasticity of R&D to a TP tax is very small. Yes, such a tax will raise R&D, but not by very much. Second, available cvidencc suggests that the private return to TP far exceeds that to R&D. Hence, unless it is found that the difference between the social and private returns to R&D is much greater than the same difference for TP expenditures, imposing a tax on TP will be welfare reducing. Indeed, the simulations in this paper suggest that the losses in terms of domestic profits could be substantial.

Table 9

AGGREGATE RESULTS OF POLICY SIMULATIONS

(The mean value from 100 random draws)

	COMPLETE SAMPLE	SCIENTIFIC FIRMS	NONSCIENTIFIC FIRMS
Simulation 1: Loosening the TP Regulations			
(NEW T) / (ORIGINAL T)*	1.999 (78.37)	2.004 (28.98)	2.005 (16.73)
(NEW R) / (ORIGINAL R)*	0.860 (76.88)	0.906 (33.36)	0.833 (26.48)
Net Marginal Change in private PDV as % of Aggregate Profits **	56.61 (78.17)	43.63 (59.01)	101.6 (134.0)
Net Marginal Change in private PDV6 as % of Aggregate Profits **	88.36 (78.90)	67.31 (59.00)	168.8 (139.2)
Simulation 2: Strengthening Foreign Patent Protection			
(NEW T) / (ORIGINAL T)*	1.007 (34.42)	1.008 (25.32)	1.003 (15.39)
(NEW R) / (ORIGINAL R)*	0.998 (59.99)	0.995 (55.45)	0.998 (24.37)
Net Marginal Change in private PDV as % of Aggregate Profits**	0.706 (27.62)	0.570 (22.94)	0.389 (18.42)
Net Marginal Change in private PDV6 as % of Aggregate Profits**	1.077 (27.45)	0.836 (22.11)	0.617 (18.55)
Simulation 3: Loosening the FDI Restrictions			
Actual Number of Firms with histories of FDI in Sample	151	91	60
% Increase in Firms with FDI**	31.08 (70.94)	31.63 (68.79)	31.08 (43.90)
(NEW T) / (ORIGINAL T)*	1.018 (14.64)	1.080 (15.94)	1.001 (4.60)
(NEW R) / (ORIGINAL R)*	1.013 (26.87)	0.995 (7.51)	1.002 (4.60)
Net Marginal Change in private PDV as % of Aggregate Profits**	1.068 (7.56)	0.389 (13.73)	0.107 (3.61)
Net Marginal Change in private PDV6 as % of Aggregate Profits**	1.770 (8.04)	0.601 (13.74)	0.215 (4.64)
Simulation 4: Abandoning a Closed Technology Policy			
Actual Number of Firms with histories of FDI in Sample	151	91	60
% Increase in Firms with FDI**	31.08 (70.94)	31.63 (68.79)	31.08 (43.90)
(NEW T) / (ORIGINAL T)*	2.100 (34.78)	2.176 (28.16)	1.947 (17.50)
(NEW R) / (ORIGINAL R)*	0.867 (62.88)	0.891 (40.12)	0.839 (27.63)
Net Marginal Change in private PDV as % of Aggregate Profits**	59.35 (76.65)	50.38 (62.91)	102.0 (132.8)
Net Marginal Change in private PDV6 as % of Aggregate Profits**	92.75 (77.38)	77.70 (62.89)	169.7 (138.5)

* Figures in parentheses next to estimates are t-statistics for the difference between the estimated ratio and 1.
** Figures in parentheses next to estimates are t-statistics for the difference between the estimated number and 0.

All t-statistics significant at .01 level.

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